Coupling between traffic and emission models for the evaluation of mobility plans

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Fairmode – Madrid

Need to integrate mobility and emission models

- Urban air quality problems mostly related to traffic. They can be tackled:
    - Technological policies: Euro classification program: Inefficient for NOx reduction in Diesel *(Carslaw and Rhys-Tyler, 2013).*
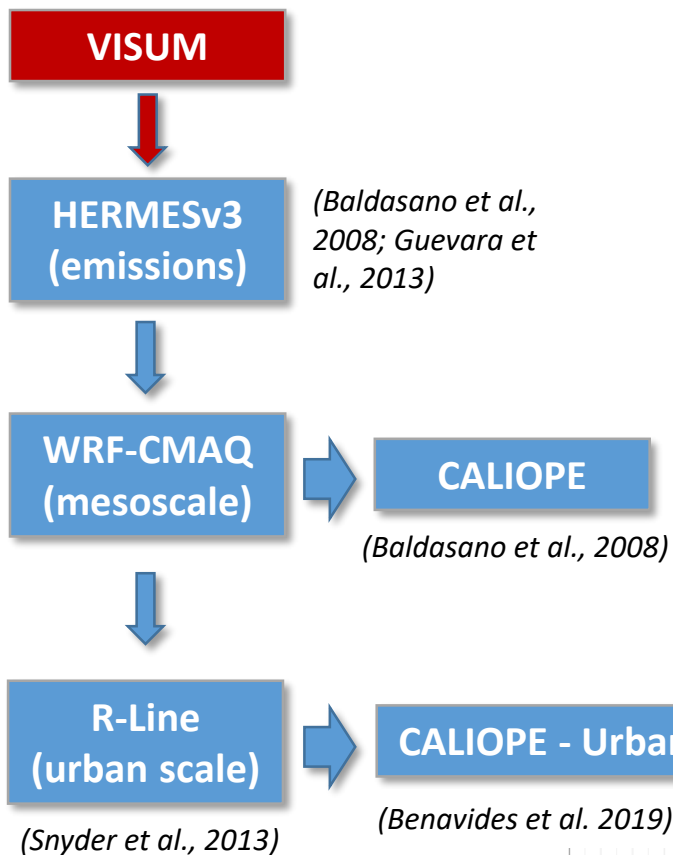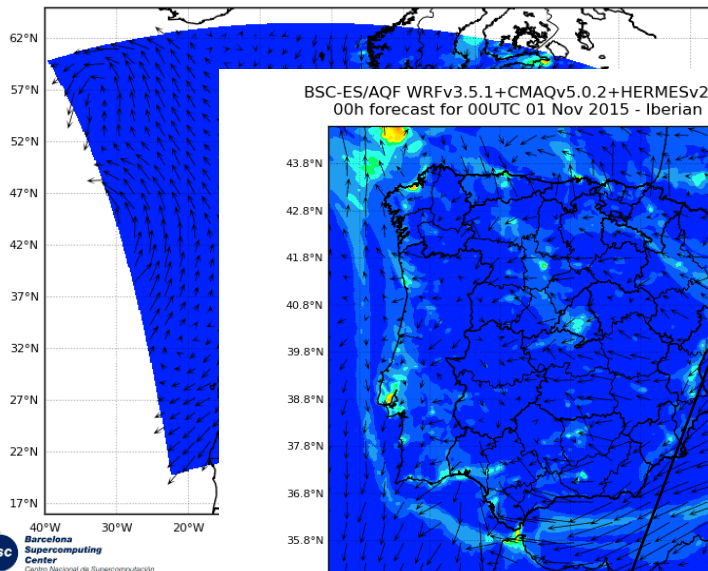   - Reduction of VKT (vehicles kilometres travelled) by mobility plans:

https://urbanaccessregulations.eu/userhome/map
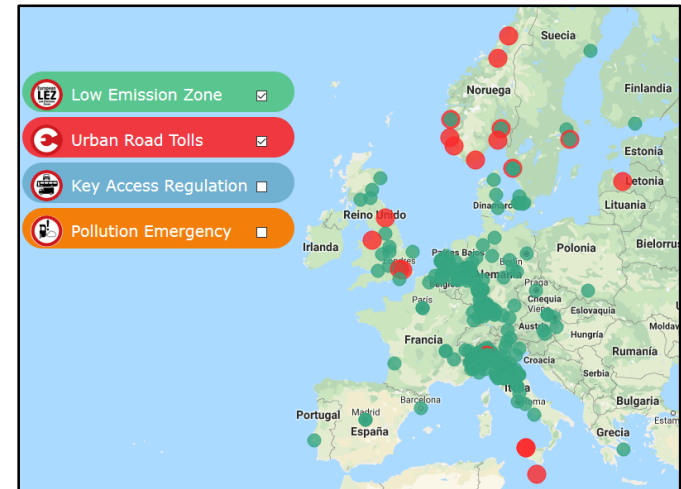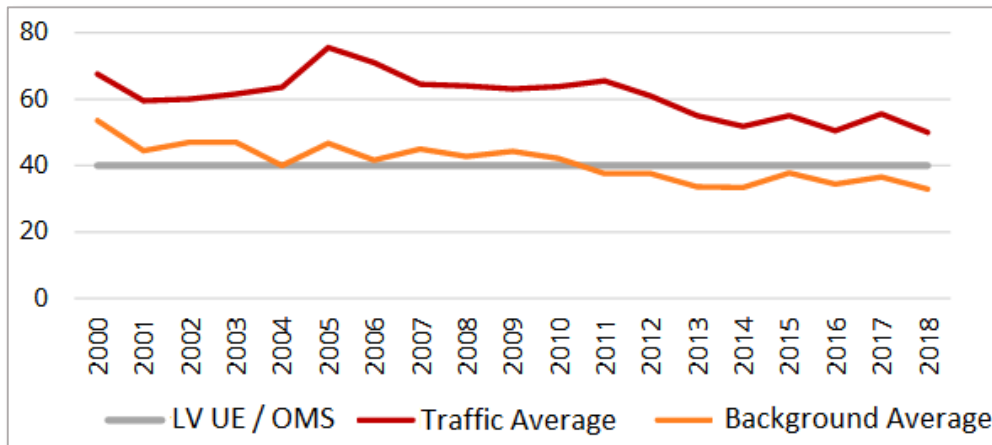
Historic NO$_2$ measured levels in Barcelona (ASPB, 2018)

Which tools or methodologies should we use to evaluate urban mobility plans?
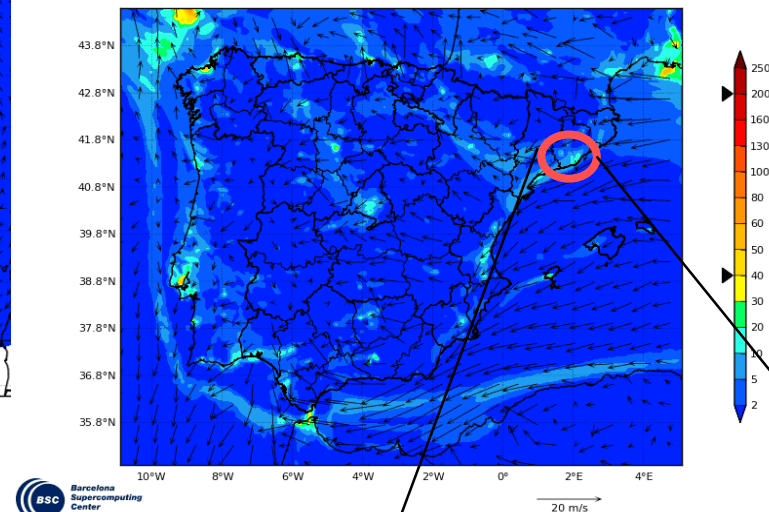
CALIOPE / CALIOPE – Urban workflow

VISUM

HERMESv3 (emissions)

(Baldasano et al., 2008; Guevara et al., 2013)

WRF-CMAQ (mesoscale) → **CALIOPE**

(Baldasano et al., 2008)

R-Line (urban scale) → **CALIOPE - Urban**

(Snyder et al., 2013)

(Benavides et al. 2019)

CALIOPE-Urban NO₂ high-resolution (10m × 10m) concentration map. Benavides et al. (2019, Geosci. Model Dev.)

Available at: www.bsc.es/caliope

BSC-ES/AQF WRFv3.5.1+CMAQv5.0.2+HERMESv2 Nitrogen Dioxide (µg/m³)
00h forecast for 00UTC 31 May 2016 - Europe Res: 12x12km

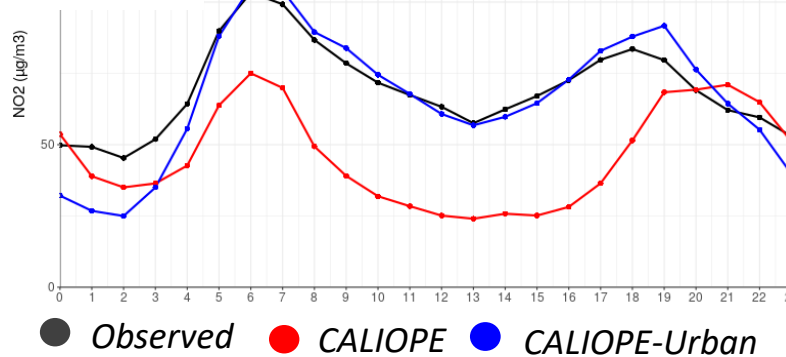BSC-ES/AQF WRFv3.5.1+CMAQv5.0.2+HERMESv2 Nitrogen Dioxide (µg/m³)
00h forecast for 00UTC 01 Nov 2015 - Iberian Peninsula Res: 4x4km

445 Valencia St.
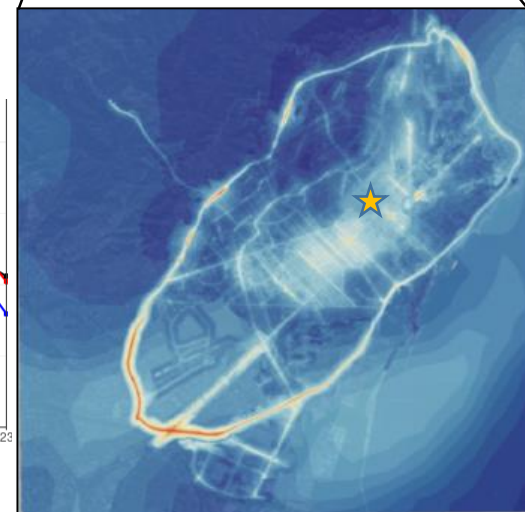
NO2 (µg/m3)

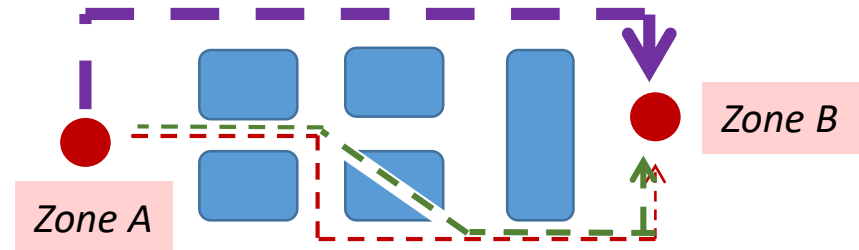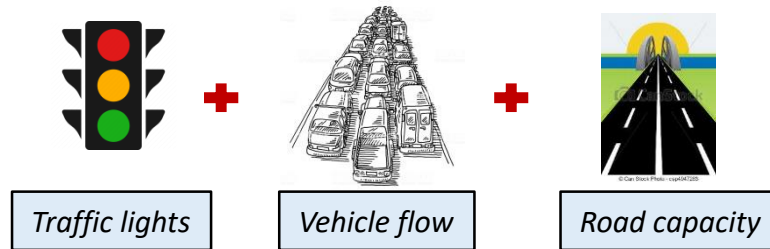● *Observed*   ● *CALIOPE*   ● *CALIOPE-Urban*

The traffic simulator

- Origin Destination matrixes OD

- Each path with difference impedance

Zone A

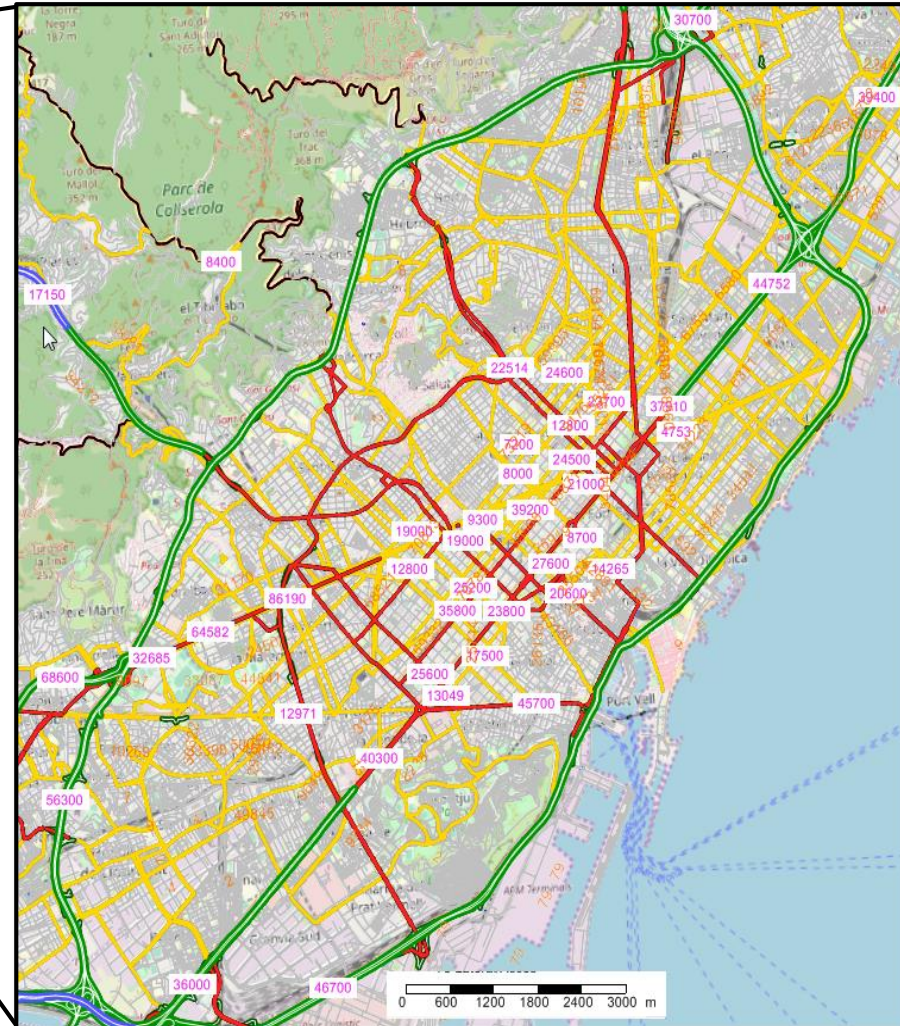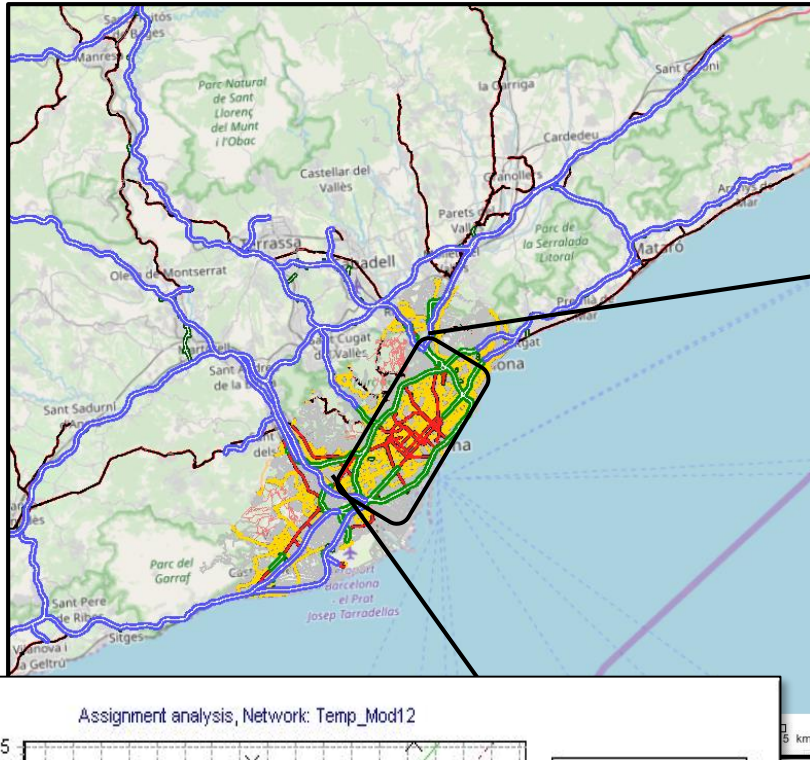Zone B

Traffic lights + Vehicle flow + Road capacity

- Traffic assigment by an iterative process achieving <u>user optimum</u>.
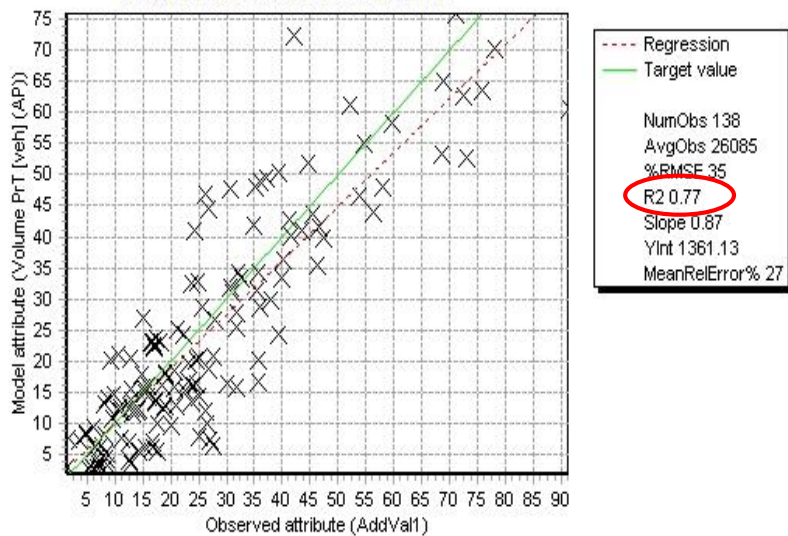
Network construction:

- Network: Open Street Map data.

- Private Tr. OD matrix data: GPS phone.

- Public Tr. OD matrix data: GPS phone + public administration counting.

- Calibration: 138 traffic flow data.

Visum network

Assignment analysis, Network: Temp_Mod12

- - - Regression
—— Target value

NumObs 138
AvgObs 26085
%RMSE 35
R2 0.77
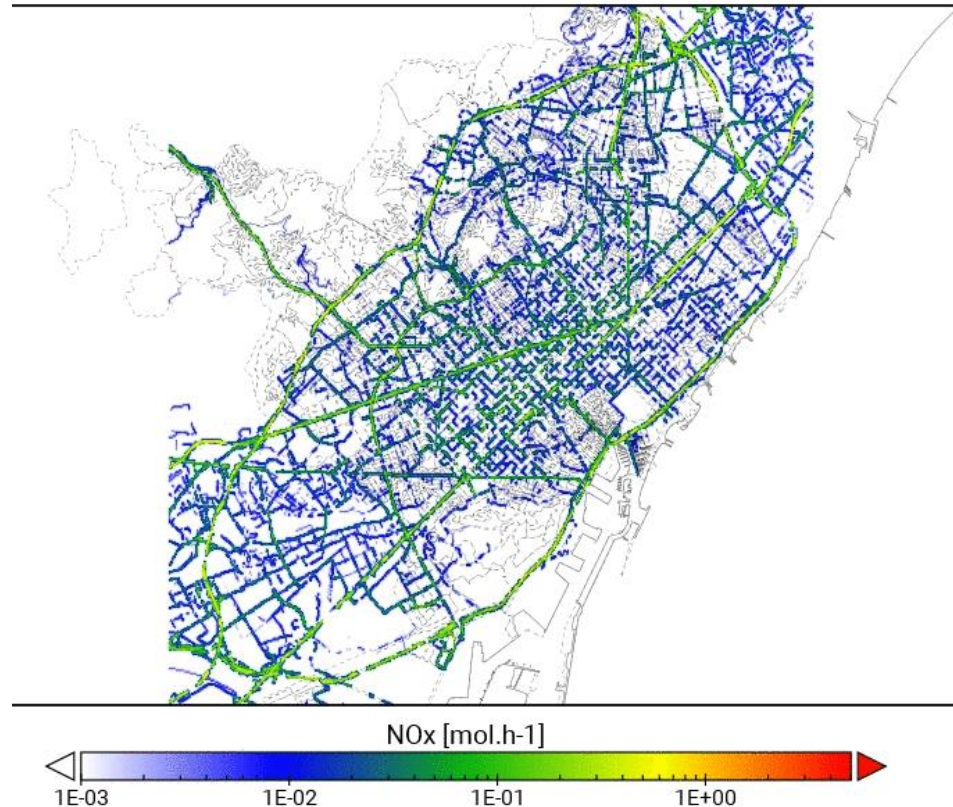Slope 0.87
YInt 1361.13
MeanRelError% 27

Visum - HERMESv3

- High resolution emission modelling system
  - Emissions estimated at the source level combining state-of-the-art methodologies with local data and meteorology (Energy and manufacturing industries, residential and commercial combustion, agriculture, road transport, other mobile sources)

NOx Visum - HERMESv3: Base Scenario (resolution 30m)
Time: 2016-11-22 00:00

- Road transport emissions
  - Street-level and vehicle-specific emissions
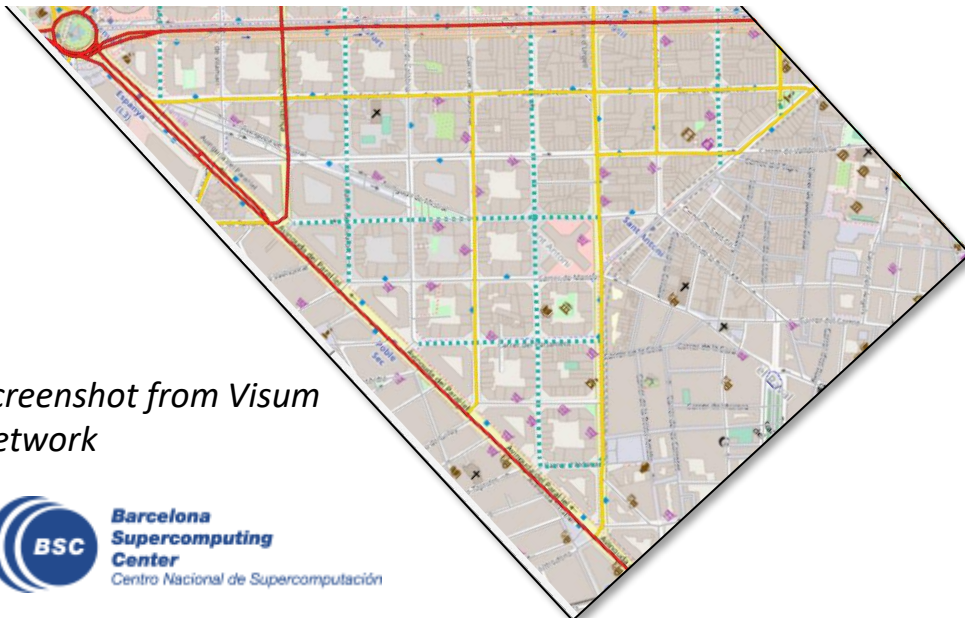 - COPERT 5 + resuspension (Pay et al., 2011)
  - AADT (Annual Average Daily Traffic) → VISUM
  - Traffic Network → VISUM
  - Volume profile → VISUM
  - Speed profile → VISUM
  - Vehicle fleet
    - RSD study (RACC-AMB, 2017)

NOx [mol.h-1]

1E-03   1E-02   1E-01   1E+00

Superblocs idea

Street type to simulate

Superblocks scenario

- Creation of a new road type: "Superblock".

- Max speed: 20 km/h
  - Link capacity: 5,250 vehicles/day
    - Estimated AADT: 3,000 to 8,000 vehicles. *(action plan superilles: St. Antoni)*

- Vehicle demand (nº of trips) kept constant

- Modification of the streets according to the reports of the city hall for each Superblock.

Screenshot from Visum network

Barcelona Supercomputing Center
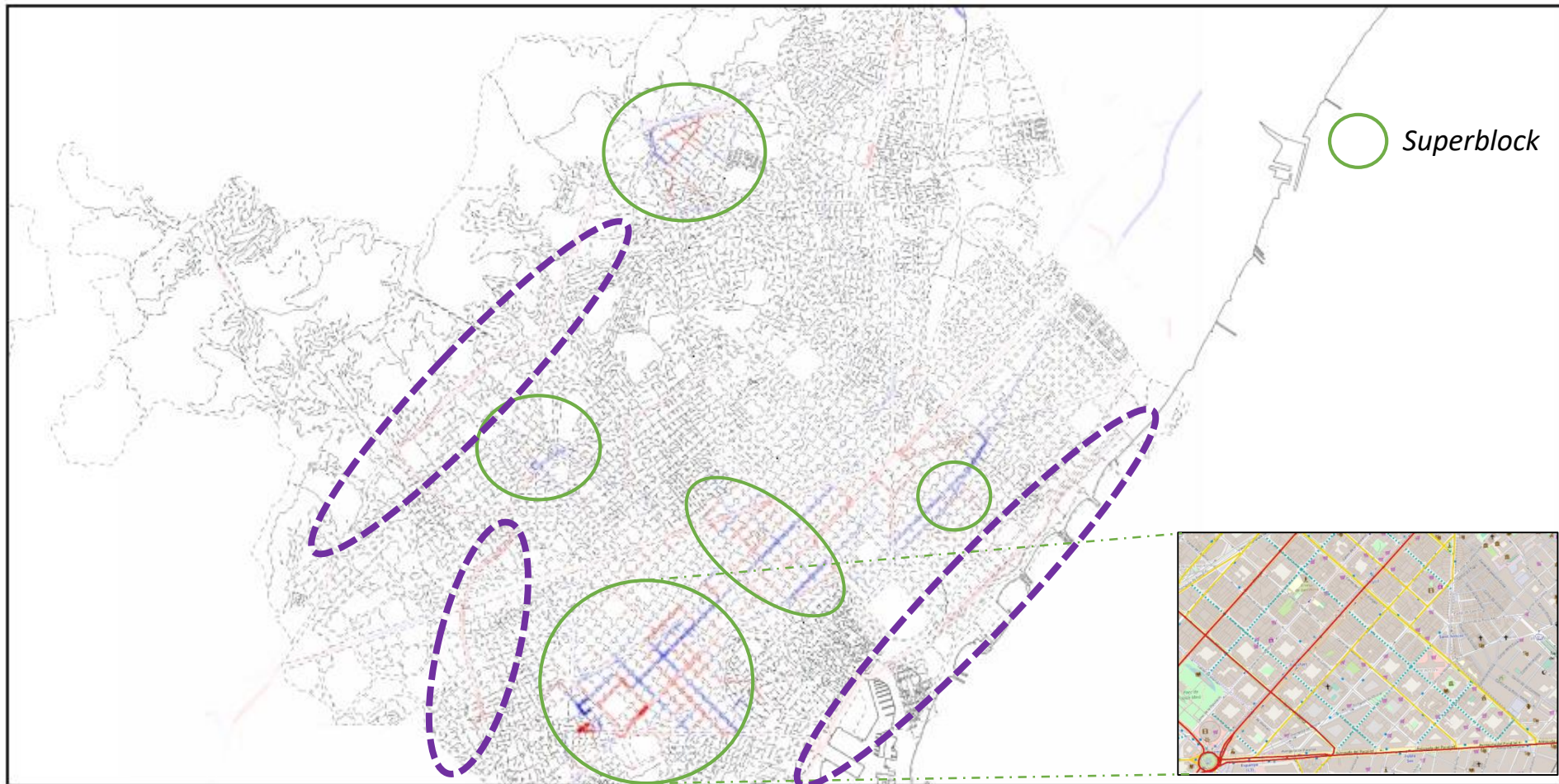Centro Nacional de Supercomputación
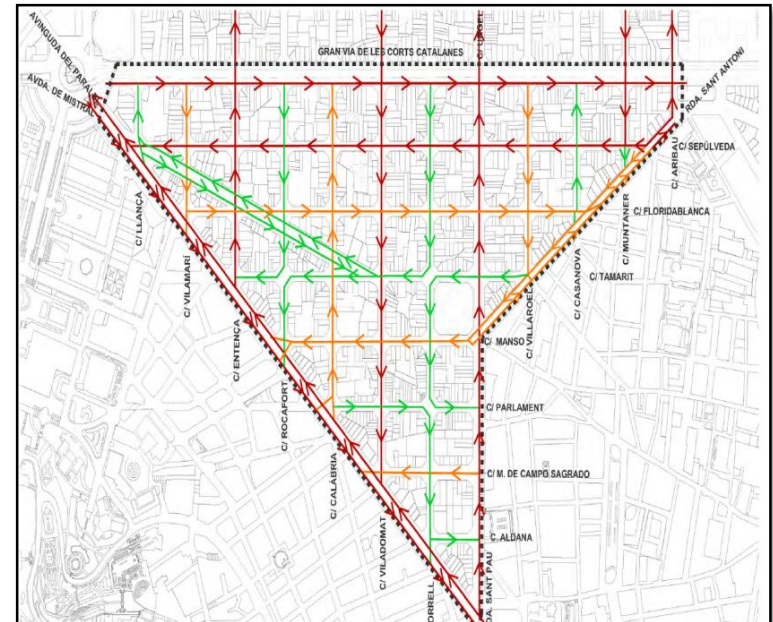
Aj. de Barcelona – "Pla d'Acció de l'àmbit de Superilles de St. Antoni." December 2017

Superblocs scenario results

NOx Difference: Superblocks - Base Scenarios (resolution 30m)

Time: 9h

Superblock

(x10) NOx [mol.h-1]

-5.0   -3.0   -1.0   1.0   3.0   5.0
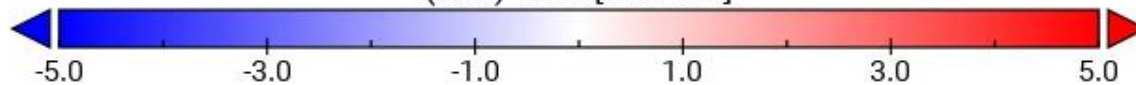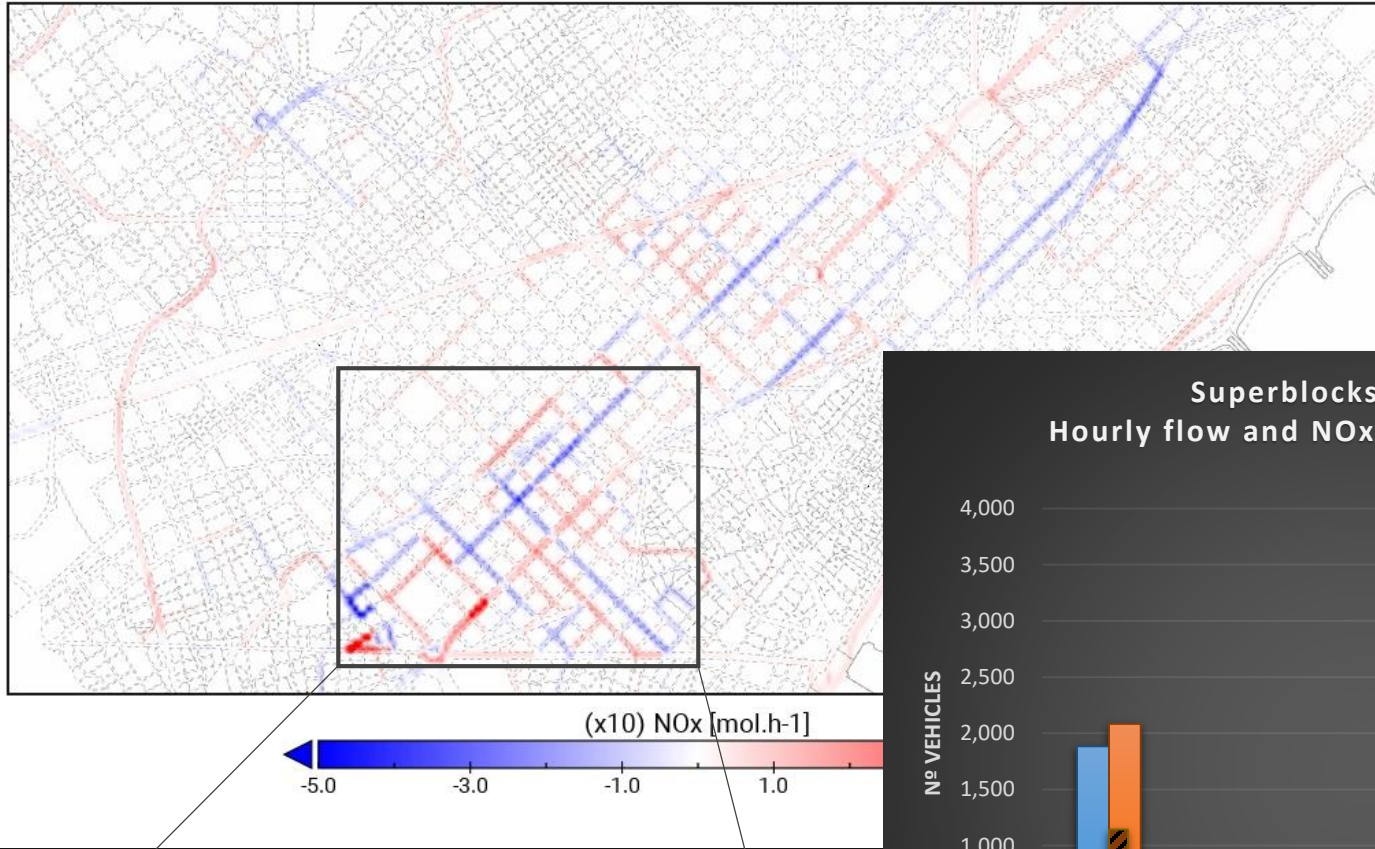
Superblocs scenario results

NOx Difference: Superblocks - Base Scenarios (resolution 30m)
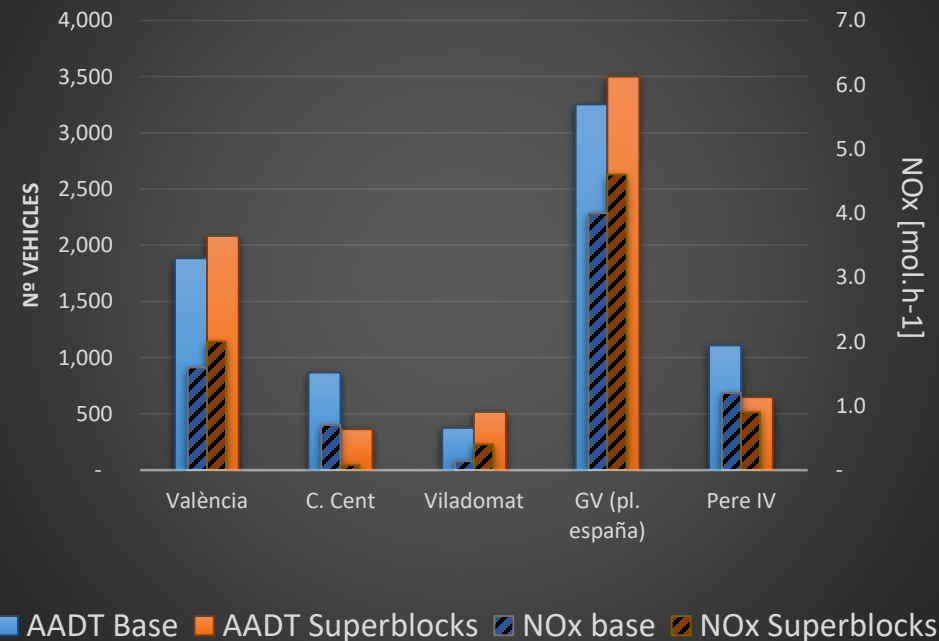Time: 9h

(x10) NOx [mol.h-1]

-5.0   -3.0   -1.0   1.0

| Total Base (24h) | 22.454 mol Nox |
| Total Superblocks (24h) | 22.743 mol NOx |

Superblocks Scenario:
Hourly flow and NOx for principal roads

Nº VEHICLES — NOx [mol.h-1]

València   C. Cent   Viladomat   GV (pl. españa)   Pere IV

■ AADT Base   ■ AADT Superblocks   ▨ NOx base   ▨ NOx Superblocks

Diagonal Tram plan

Current disposition

Proposed disposition

New Tram line — — —
Current Tram line – – –
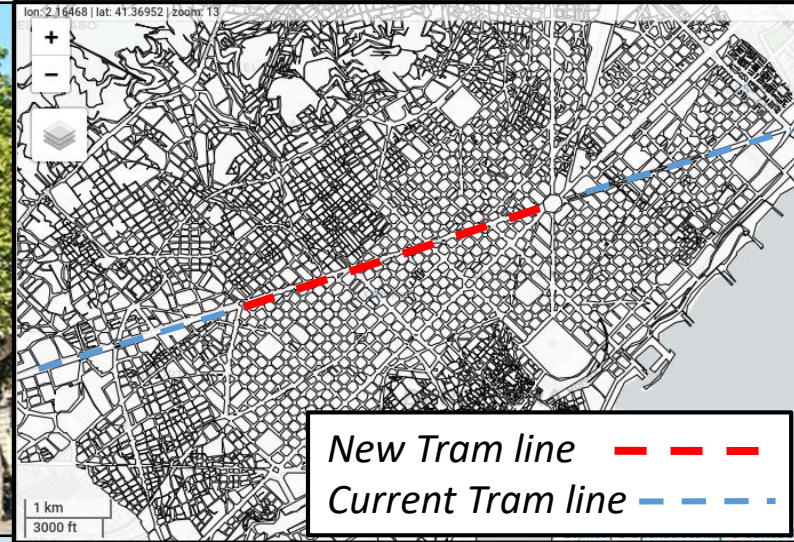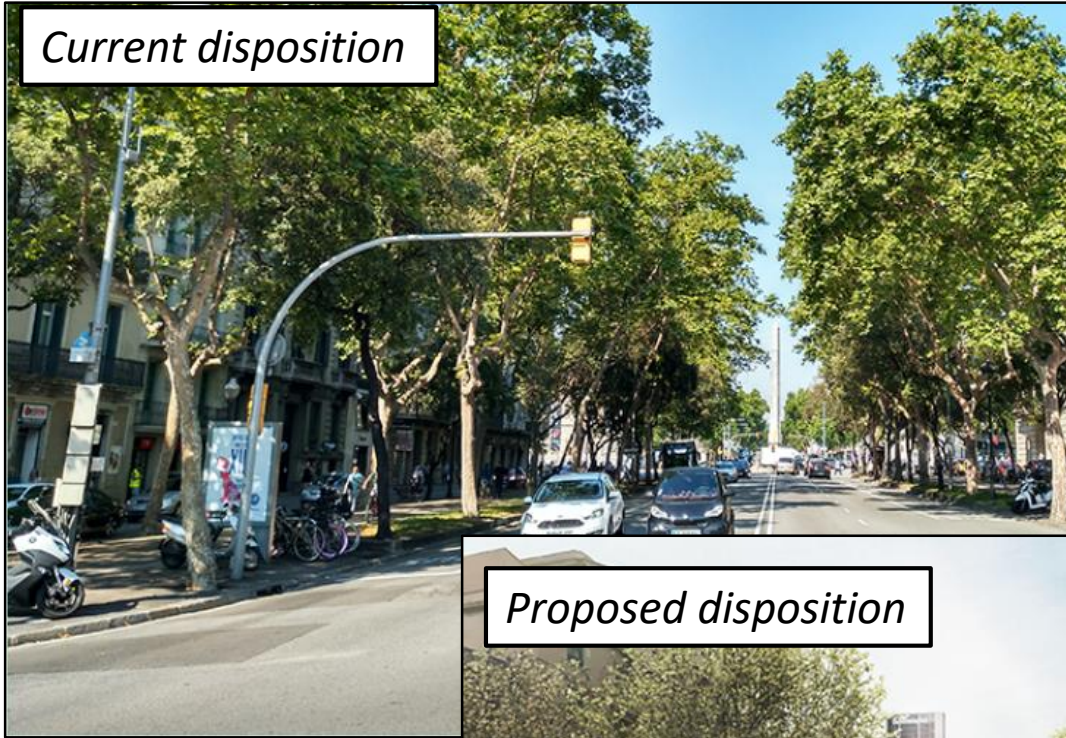
Diagonal Tram scenario results

NOx difference: Tram - Base Scenarios (30m resolution)

Time: 9h

(x10) NOx [mol.

-12.0   -7.2   -2.4   2.
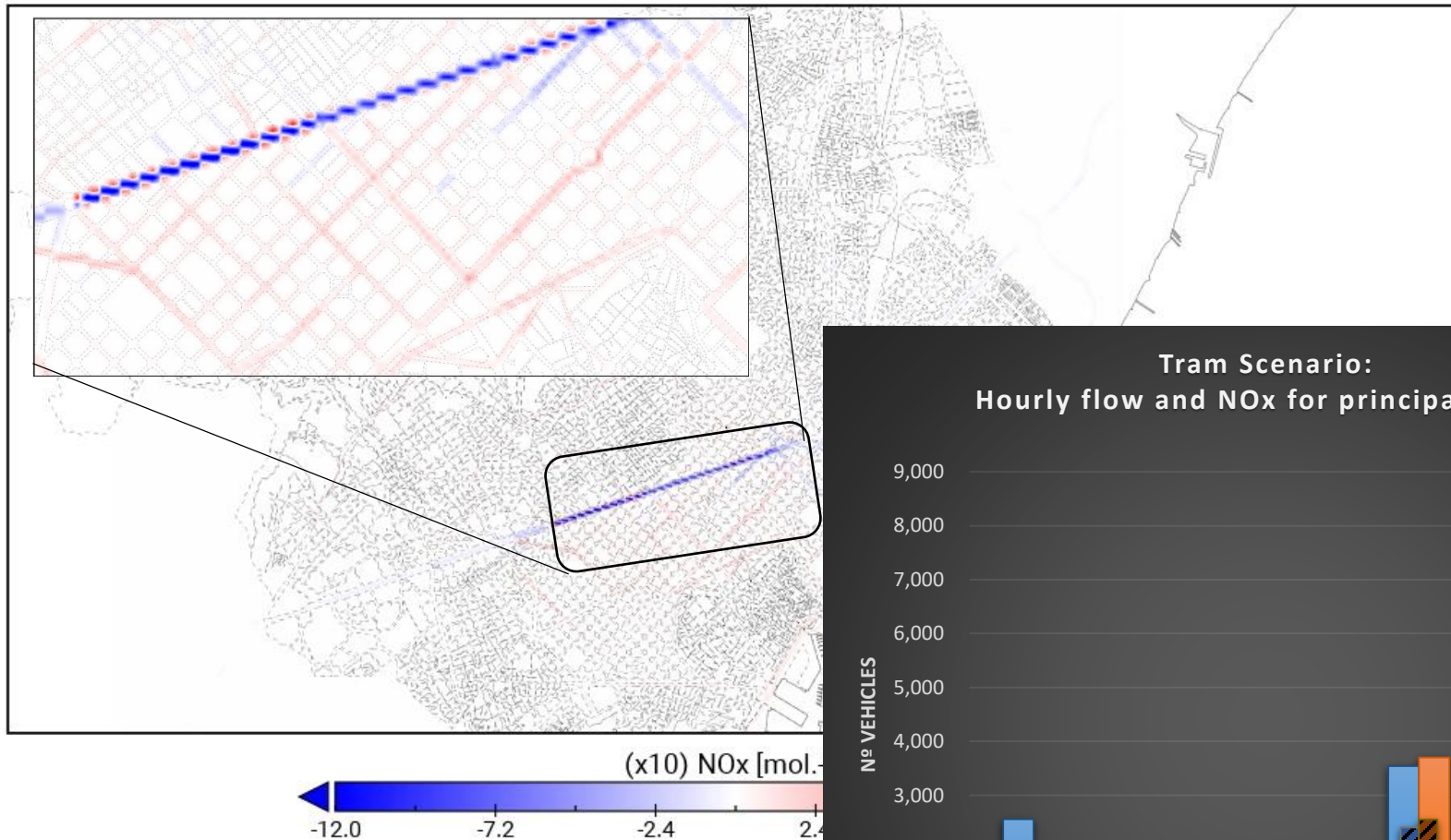
Total Base (24h)	11743 mol NOx
Total Tram (24h)	11180 mol NOx

Tram Scenario:
Hourly flow and NOx for principal roads

■ AADT Base   ■ AADT Tram   ▨ Nox base   ▨ NOx TRAM
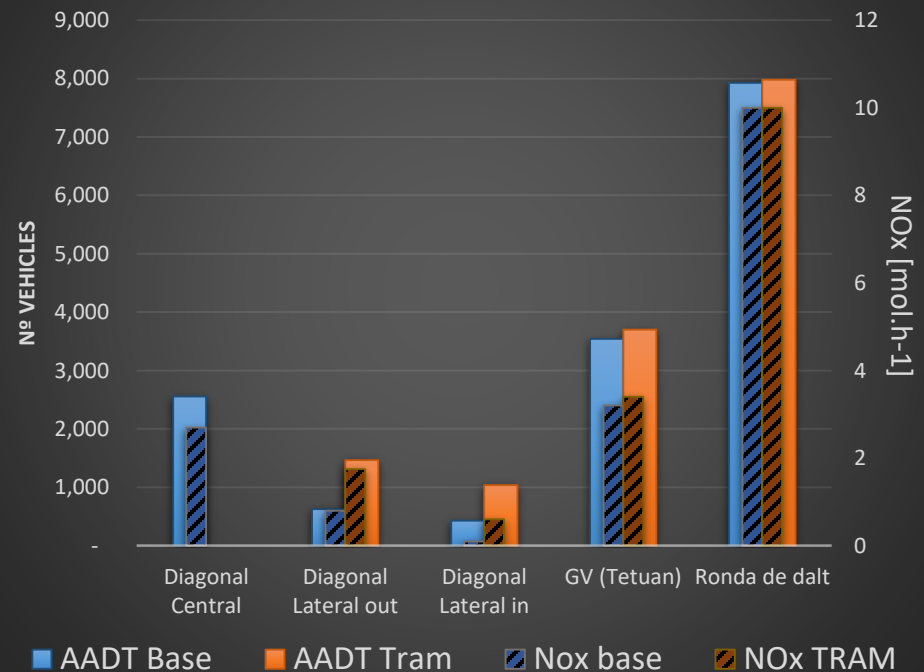
Tram+Superblocks scenario results

Tram+Superblocks Scenario:
Hourly flow and NOx for principal roads

Total Base (24h)	63274 mol NOx
Total Tram+SB (24h)	64058 mol NOx

Difference: Tram+Superilles - Base Scenarios. [x10 mol.h-1]
Time: 9h

desc no (mol.h-1)

Data Min = -17.2, Max = 11.2
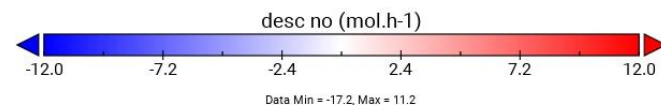
Future work

- Coupling the public transport network

- Design and implementation of other mobility policies (congestion charge)

- Air quality evaluation:
  - Mesoscale CALIOPE
  - Urban scale (CALIOPE – Urban)

- Comparison between mesoscale (COPERT 5) and instantaneous (PHEMLight) emission models for hot spots
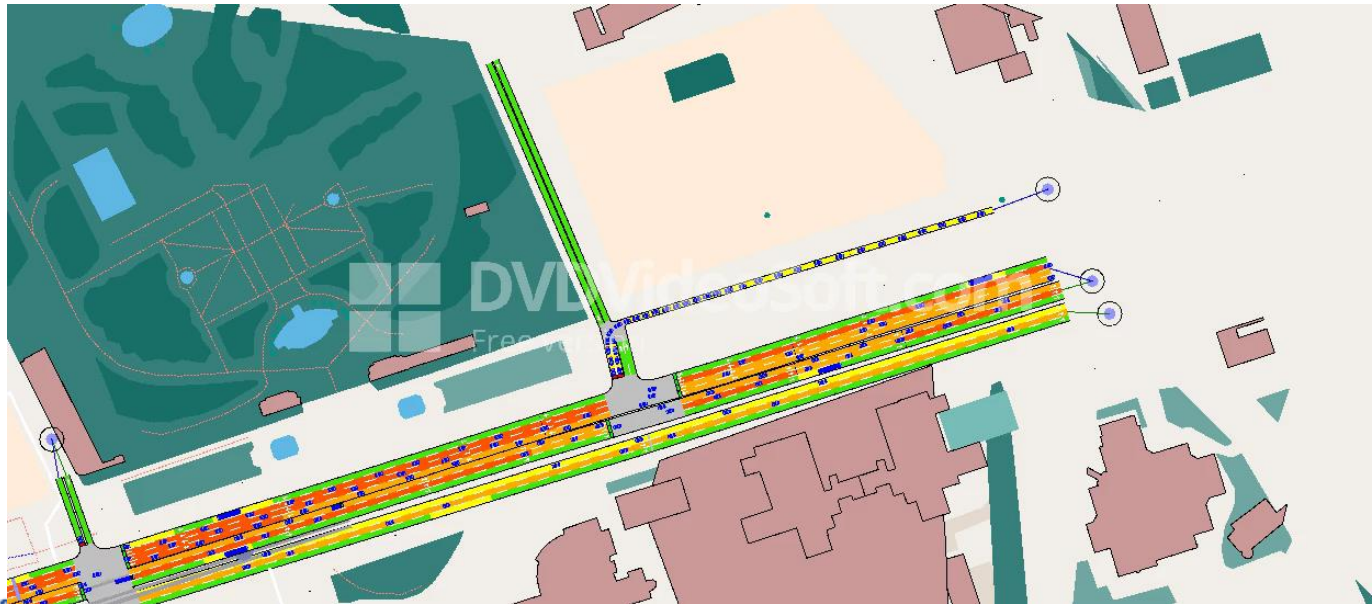
Thank you for your attention

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Future work

- Instantaneous emission models for hot spots
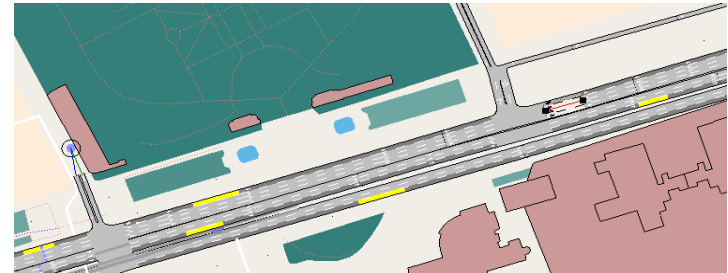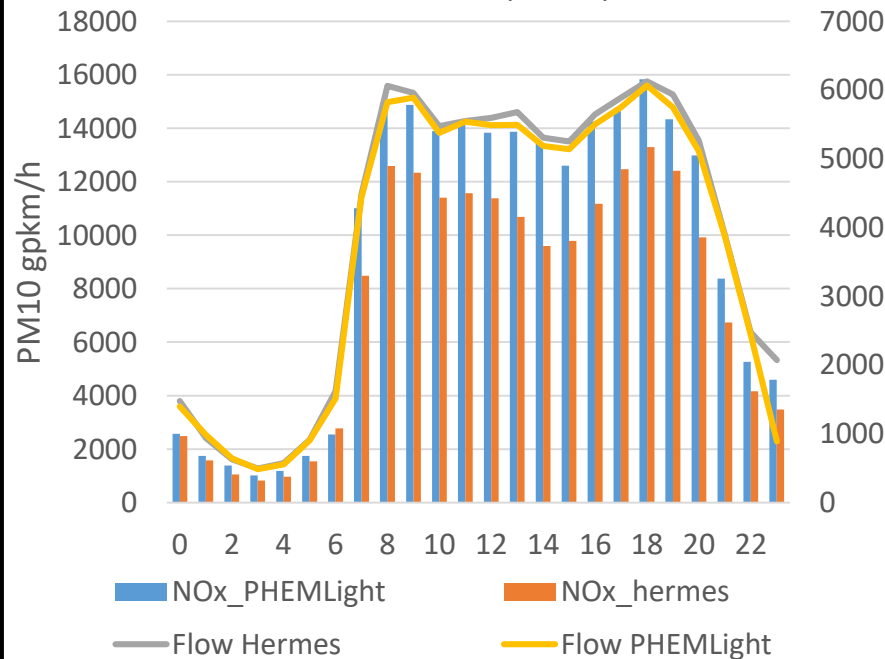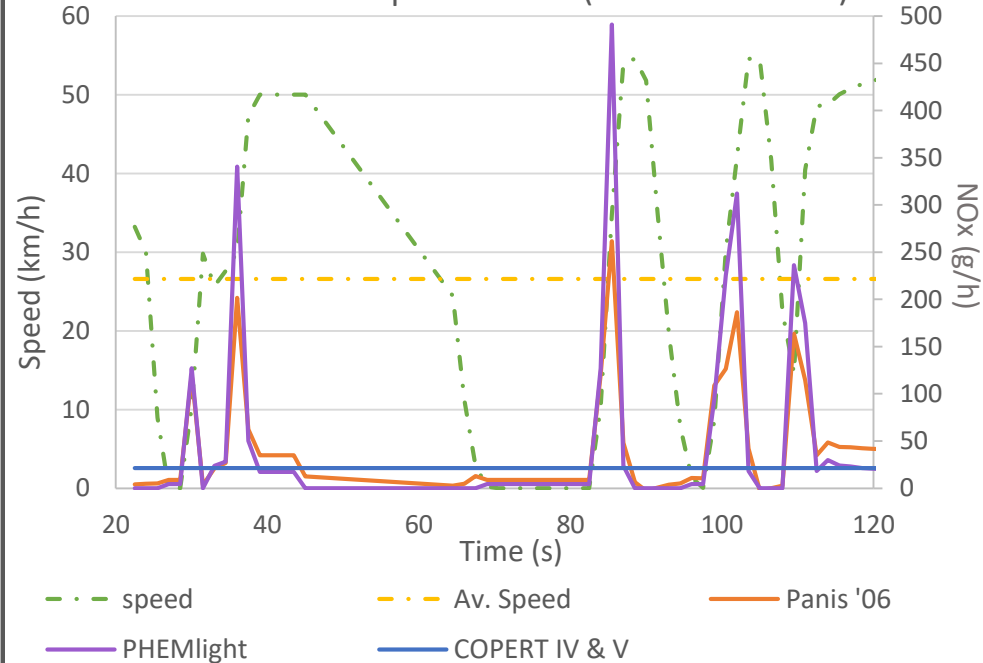
Future work

- Congestion charge scenario
  - $Impedance\ [s]\ =\ Tcur\ + Toll\_Tax$
    - $Tcur = T_0 * (1 + a \cdot sat^b)$ ← Total travel time
    - $Toll\_Tax[s] = \dfrac{2\ €}{0{,}005\ €/s}$ = 400 seconds

+400 seconds

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